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Optimal Design of Coreless Axial Flux Permanent Magnet Synchronous Generator with Reduced Cost Considering Improved PM Leakage Flux Model

Ali Daghigh,[1] Hamid Javadi,[2] and Hossein Torkaman[2]
[1]Department of Electrical Engineering, Shabestar Branch, Islamic Azad University, Shabestar, Iran
[2]Faculty of Electrical Engineering, Shahid Beheshti University, A. C., Tehran, Iran

CONTENTS

Abstract—This paper presents an optimal design of coreless axial flux permanent magnet (AFPM) synchronous generator using particle swarm optimization method based on sizing equations of the machine. The design optimization is performed in order to reduce the active material cost of the generator. General practical and mechanical limitations are considered as optimization constraints. A magnetic circuit model based on quasi three-dimensional (3-D) model of the coreless AFPM machine is taken into account to calculate the permanent magnet leakage flux (PMLF) accuracy. A computer-aided program is evaluated according to the proposed optimized design procedure that is used to design a 2-kW, 16-pole AFPM generator with two rotors and one coreless stator. Finally, the 3-D finite-element model (FEM) of the machine is prepared to confirm the validity of the proposed PMLF model and proposed optimized design algorithm.

1. INTRODUCTION

Axial flux permanent magnet (AFPM) synchronous machines have been taken into consideration in recent years due to their high torque density, compact structure, and high diameter to machine length ratio, which made them suitable for low-speed applications with high number of poles. Depending on the application and desired design characteristics, they have stators with ferromagnetic or air cores [1]. Air-cored AFPM machines have been considered in a diverse range of applications, such as direct drive wind turbine [2, 3], electrical vehicles [4], and storage systems [5]. These coreless machines have the advantages of lightweight, high efficiency, no cogging torque, and simple construction. The coreless structure of stator with large effective air-gap length results in reduced harmonic content of air-gap flux density and induced voltage. On the other hand, because of the increased non-magnetic air-gap length, PM leakage flux is increased and coreless machine uses more PM material in comparison to iron core ones. Considering advantages and disadvantages of coreless machine, it

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Address correspondence to Ali Daghigh, Department of Electrical Engineering, Shabestar Branch, Islamic Azad University, Shabestar, Iran. E-mail: a_daghigh@sbu. ac.ir
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